this subpart is used to calculate total annual production process emissions from semiconductor manufacturing. Set equal to 1 when Equation I–4 of this subpart is used to calculate total annual production process emissions from MEMS, LCD, or PV manufacturing.

E_i = Annual production process emissions of input gas i for threshold applicability purposes (metric tons Co_2e), as calculated in Equations I–1, I–2 or I–3 of this subpart.

i = Input gas.

(b) You must calculate annual manufacturing capacity of a facility using Equation I–5 of this subpart.

$$S = \sum_{x}^{12} W_x \quad \text{(Eq. I-5)}$$

where:

S = 100 percent of annual manufacturing capacity of a facility (m^2).

W_X = Maximum substrate starts of fab f in month x (m^2 per month).

x = Month.

[75 FR 74818, Dec. 1, 2010, as amended at 77 FR 10380, Feb. 22, 2012; 78 FR 68202, Nov. 13, 2013]

§ 98.92 GHGs to report.

(a) You must report emissions of fluorinated GHGs (as defined in § 98.6), N_2O, and fluorinated heat transfer fluids (as defined in § 98.98). The fluorinated GHGs and fluorinated heat transfer fluids that are emitted from electronics manufacturing production processes include, but are not limited to, those listed in Table I–2 to this subpart. You must individually report, as appropriate:

(1) Fluorinated GHGs emitted.

(2)–(3) [Reserved]

(4) N_2O emitted from chemical vapor deposition and other electronics manufacturing processes.

(5) Emissions of fluorinated heat transfer fluids.

(6) All fluorinated GHGs and N_2O consumed.

(b) CO_2, CH_4, and N_2O combustion emissions from each stationary combustion unit. You must calculate and report these emissions under subpart C of this part (General Stationary Fuel Combustion Sources) by following the requirements of subpart C of this part.

[75 FR 74818, Dec. 1, 2010, as amended at 77 FR 10380, Feb. 22, 2012; 78 FR 68202, Nov. 13, 2013]

§ 98.93 Calculating GHG emissions.

(a) You must calculate total annual emissions of each fluorinated GHG emitted by electronics manufacturing production processes from each fab (as defined in § 98.98) at your facility, including each input gas and each by-product gas. You must use either default gas utilization rates and by-product formations rates according to the procedures in paragraph (a)(1), (a)(2), or (a)(6) of this section, as appropriate, or the stack test method according to paragraph (i) of this section, to calculate emissions of each input gas and each by-product gas.

(1) If you manufacture semiconductors, you must adhere to the procedures in paragraphs (a)(2)(i) through (iii) of this section. You must calculate annual emissions of each input gas and of each by-product gas using Equations I–6 and I–7, respectively. If your fab uses less than 50 kg of a fluorinated GHG in one reporting year, you may calculate emissions as equal to your fab's annual consumption for that specific gas as calculated in Equation I–11 of this subpart, plus any by-product emissions of that gascalculated under this paragraph (a).

$$\text{Pr}\,ocesstypeE_i = \sum_{j=1}^{N} E_{ij} \qquad \text{(Eq. I-6)}$$

Where:

$ProcesstypeE_i$ = Annual emissions of input gas i from the process type on a fab basis (metric tons).

E_{ij} = Annual emissions of input gas i from process sub-type or process type j as calculated in Equation I–8 of this subpart (metric tons).

N = The total number of process sub-types j that depends on the electronics manufacturing fab and emission calculation methodology. If E_{ij} is calculated for a process type j in Equation I–8 of this subpart, N = 1.

i = Input gas.

j = Process sub-type or process type.

$$\text{Pr}\,ocesstypeBE_k = \sum_{j=1}^{N} \sum_{i} BE_{ijk} \qquad \text{(Eq. I-7)}$$

Where:

$ProcesstypeBE_k$ = Annual emissions of by-product gas k from the processes type on a fab basis (metric tons).

BE_{ijk} = Annual emissions of by-product gas k formed from input gas i used for process sub-type or process type j as calculated in Equation I–9 of this subpart (metric tons).

N = The total number of process sub-types j that depends on the electronics manufacturing fab and emission calculation methodology. If BE_{ijk} is calculated for a process type j in Equation I–9 of this subpart, N = 1.

i = Input gas.

j = Process sub-type, or process type.

k = By-product gas.

(i) You must calculate annual fab-level emissions of each fluorinated GHG used for the plasma etching/wafer cleaning process type using default utilization and by-product formation rates as shown in Table I–3 or I–4 of this subpart, and by using Equations I–8 and I–9 of this subpart.

$$E_{ij} = C_{ij} * (1 - U_{ij}) * \left(1 - (a_{ij} * d_{ij} * UT_{ij})\right) * 0.001 \qquad \text{(Eq. I-8)}$$

Where:

E_{ij} = Annual emissions of input gas i from process sub-type or process type j, on a fab basis (metric tons).

C_{ij} = Amount of input gas i consumed for process sub-type or process type j, as calculated in Equation I–13 of this subpart, on a fab basis (kg).

U_{ij} = Process utilization rate for input gas i for process sub-type or process type j (expressed as a decimal fraction).

a_{ij} = Fraction of input gas i used in process sub-type or process type j with abatement systems, on a fab basis (expressed as a decimal fraction).

d_{ij} = Fraction of input gas i destroyed or removed in abatement systems connected to process tools where process sub-type, or process type j is used, on a fab basis (expressed as a decimal fraction). This is zero unless the facility adheres to the requirements in § 98.94(f).

UT_{ij} = The average uptime factor of all abatement systems connected to process tools in the fab using input gas i in process sub-type or process type j, as calculated in Equation I–15 of this subpart, on a fab basis (expressed as a decimal fraction).

0.001 = Conversion factor from kg to metric tons.

i = Input gas.

j = Process sub-type or process type.

$$\cancel{BE_{ijk} = B_{ijk} * C_{ij} * (1 - a_{ij} * d_{jk}) * 0.001}$$

$$BE_{ijk} = B_{ijk} * C_{ij} * \left(1 - \left(a_{ij} * d_{jk} * UT_{ijk}\right)\right) * 0.001 \qquad \text{(Eq. I-9)}$$

Where:

BE_{ijk} = Annual emissions of by-product gas k formed from input gas i from process sub-type or process type j, on a fab basis (metric tons).

B_{ijk} = By-product formation rate of gas k created as a by-product per amount of input gas i (kg) consumed by process sub-type or process type j (kg).

C_{ij} = Amount of input gas i consumed for process sub-type, or process type j, as calculated in Equation I–13 of this subpart, on a fab basis (kg).

a_{ij} = Fraction of input gas i used for process sub-type, or process type j with abatement systems, on a fab basis (expressed as a decimal fraction).

d_{jk} = Fraction of by-product gas k destroyed or removed in abatement systems connected to process tools where process sub-type, or process type j is used, on a fab basis (expressed as a decimal fraction). This is zero unless the facility adheres to the requirements in §98.94(f).

UT_{ijk} = The average uptime factor of all abatement systems connected to process tools in the fab emitting by-product gas k, formed from input gas i in process sub-type or process type j, on a fab basis (expressed as a decimal fraction). For this equation, UT_{ijk} is assumed to be equal to UT_{ij} as calculated in Equation I–15 of this subpart.

0.001 = Conversion factor from kg to metric tons.

i = Input gas.

j = Process sub-type or process type.

k = By-product gas.

(ii) You must calculate annual fab-level emissions of each fluorinated GHG used for each of the process sub-types associated with the chamber cleaning process type, including in-situ plasma chamber clean, remote plasma chamber clean, and in-situ thermal chamber clean, using default utilization and by-product formation rates as shown in Table I–3 or I–4 of this subpart, and by using Equations I–8 and I–9 of this subpart.

(iii) If default values are not available for a particular input gas and process type or sub-type combination in Tables I–3 or I–4, you must follow the procedures in paragraph (a)(6) of this section.

(2) If you manufacture MEMS, LCDs, or PVs, you must calculate annual fab-level emissions of each fluorinated GHG used for the plasma etching and chamber cleaning process types using default utilization and by-product formation rates as shown in Table I–5, I–6, or I–7 of this subpart, as appropriate, and by using Equations I–8 and I–9 of this subpart. If default values are not available for a particular input gas and process type or sub-type combination in Tables I–5, I–6, or I–7, you must follow the procedures in paragraph (a)(6) of this section. If your fab uses less than 50 kg of a fluorinated GHG in one reporting year, you may calculate emissions as equal to your fab's annual consumption for that specific gas as calculated in Equation I–11 of this subpart, plus any by-product emissions of that gas calculated under this paragraph (a).

(3)–(5) [Reserved]

(6) If you are required, or elect, to perform calculations using default emission factors for gas utilization and by-product formation rates according to the procedures in paragraphs (a)(1) or (a)(2) of this section, and default values are not available for a particular input gas and process type or sub-type combination in Tables I–3, I–4, I–5, I–6, or I–7, you must use the utilization and by-product formation rates of zero and use Equations I–8 and I–9 of this subpart.

(b) You must calculate annual fab-level N_2O emissions from all chemical vapor deposition processes and from the aggregate of all other electronics manufacturing production processes using Equation I–10 of this subpart and the methods in paragraphs (b)(1) and (2) of this section. If your fab uses less than 50 kg of N_2O in one reporting year, you may calculate fab emissions as equal to your fab's annual consumption for N_2O as calculated in Equation I–11 of this subpart.

$$E(N_2O)_j = C_{N_2O,j} * \left(1 - U_{N_2O,j}\right) * \left(1 - \left(a_{N_2O,j} * d_{N_2O,j} * UT_{N2O}\right)\right) * 0.001 \qquad \text{(Eq. I-10)}$$

Where:

$E(N_2O)_j$ = Annual emissions of N_2O for N_2O-using process j, on a fab basis (metric tons).

$C_{N2O,j}$ = Amount of N_2O consumed for N_2O-using process j, as calculated in Equation I–13 of this subpart and apportioned to N_2O process j, on a fab basis (kg).

$U_{N2O,j}$ = Process utilization factor for N_2O-using process j (expressed as a decimal fraction) from Table I–8 of this subpart.

$a_{N2O,j}$ = Fraction of N_2O used in N_2O-using process j with abatement systems, on a fab basis (expressed as a decimal fraction).

$d_{N2O,j}$ = Fraction of N_2O for N_2O-using process j destroyed or removed in abatement systems connected to process tools where process j is used, on a fab basis (expressed as a decimal fraction). This is zero unless the facility adheres to the requirements in § 98.94(f).

UT_{N2O} = The average uptime factor of all the abatement systems connected to process tools in the fab that use N_2O, as calculated in Equation I–15 of this subpart, on a fab basis (expressed as a decimal fraction). For purposes of calculating the abatement system uptime for N_2O using process tools, in Equation I–15 of this subpart, the only input gas i is N_2O, j is the N_2O using process, and p is the N_2O abatement system connected to the N_2O using tool.

0.001 = Conversion factor from kg to metric tons.

j = Type of N_2O-using process, either chemical vapor deposition or all other N_2O-using manufacturing processes.

(1) You must use the factor for N_2O utilization for chemical vapor deposition processes as shown in Table I–8 to this subpart.

(2) You must use the factor for N_2O utilization for all other manufacturing production processes other than chemical vapor deposition as shown in Table I–8 to this subpart.

(c) You must calculate total annual input gas i consumption on a fab basis for each fluorinated GHG and N_2O using Equation I–11 of this subpart. Where a gas supply system serves more than one fab, Equation I–11 is applied to that gas which has been apportioned to each fab served by that system using the apportioning factors determined in accordance with § 98.94(c).

$$C_i = (I_{Bi} - I_{Ei} + A_i - D_i) \qquad \text{(Eq. I-11)}$$

where:

C_i = Annual consumption of input gas i, on a fab basis (kg per year).

I_{Bi} = Inventory of input gas i stored in containers at the beginning of the reporting year, including heels, on a fab basis (kg). For containers in service at the beginning of a reporting year, account for the quantity in these containers as if they were full.

I_{Ei} = Inventory of input gas i stored in containers at the end of the reporting year, including heels, on a fab basis (kg). For containers in service at the end of a reporting year, account for the quantity in these containers as if they were full.

A_i = Acquisitions of input gas i during the year through purchases or other transactions, including heels in containers returned to the electronics manufacturing facility, on a fab basis (kg).

D_i = Disbursements of input gas i through sales or other transactions during the year, including heels in containers returned by the electronics manufacturing facility to the chemical supplier, as calculated using Equation I–12 of this subpart, on a fab basis (kg).

i = Input gas.

(d) You must calculate disbursements of input gas i using fab-wide gas-specific heel factors, as determined in § 98.94(b), and by using Equation I–12 of this subpart. Where a gas supply system serves more than one fab, Equation I–12 is applied to that gas which has been apportioned to each fab served by that system using the apportioning factors determined in accordance with §98.94(c).

$$D_i = \sum_{l=1}^{M} \left(h_{il} * N_{il} * F_{il} \right) + X_i \quad \text{(Eq. I-12)}$$

where:

D_i = Disbursements of input gas i through sales or other transactions during the reporting year on a fab basis, including heels in containers returned by the electronics manufacturing fab to the gas distributor (kg).

h_{il} = Fab-wide gas-specific heel factor for input gas i and container size and type l (expressed as a decimal fraction), as determined in §98.94(b). If your fab uses less than 50 kg of a fluorinated GHG or N_2O in one reporting year, you may assume that any h_{il} for that fluorinated GHG or N_2O is equal to zero.

N_{il} = Number of containers of size and type l returned to the gas distributor containing the standard heel of input gas i.

F_{il} = Full capacity of containers of size and type l containing input gas i, on a fab basis (kg).

X_i = Disbursements under exceptional circumstances of input gas i through sales or other transactions during the year, on a fab basis (kg). These include returns of containers whose contents have been weighed due to an exceptional circumstance as specified in §98.94(b)(4).

i = Input gas.

l = Size and type of gas container.

M = The total number of different sized container types on a fab basis. If only one size and container type is used for an input gas i, M=1

(e) You must calculate the amount of input gas i consumed, on a fab basis, for each process sub-type or process type j, using Equation I–13 of this subpart. Where a gas supply system serves more than one fab, Equation I–13 is applied to that gas which has been apportioned to each fab served by that system using the apportioning factors determined in accordance with §98.94(c). If you elect to calculate emissions using the stack test method in paragraph (i) of this section, you must calculate the amount of input gas i consumed on the applicable basis by using an appropriate apportioning factor. For example, when calculating fab-level emissions of each fluorinated GHG consumed using Equation I–21 of this section, you must substitute the term fij with the appropriate apportioning factor to calculate the total consumption of each fluorinated GHG in tools that are vented to stack systems that are tested.

$$C_{ij} = f_{ij} * C_i \quad \text{(Eq. I-13)}$$

where:

$C_{i,j}$ = The annual amount of input gas i consumed, on a fab basis, for process subtype or process type j (kg).

$f_{i,j}$ = Process sub-type-specific or process type-specific j, input gas i apportioning factor (expressed as a decimal fraction), as determined in accordance with §98.94(c).

C_i = Annual consumption of input gas i, on a fab basis, as calculated using Equation I–11 of this subpart (kg).

i = Input gas.

j = Process sub-type or process type.

(f) [Reserved]

(g) If you report controlled emissions pursuant to §98.94(f), you must calculate the uptime of all the abatement systems for each combination of input gas or by-product gas, and process subtype or process type, by using Equation I–15 of this subpart.

$$UT_{ij} = 1 - \frac{\sum_p Td_{ijp}}{\sum_p UT_{ijp}} \qquad \text{(Eq. I-15)}$$

Where:

UT_{ij} = The average uptime factor of all abatement systems connected to process tools in the fab using input gas i in process sub-type or process type j (expressed as a decimal fraction).

Td_{ijp} = The total time, in minutes, that abatement system p, connected to process tool(s) in the fab using input gas i in process sub-type or process type j, is not in operational mode, as defined in § 98.98, when at least one of the tools connected to abatement system p is in operation.

UT_{ijp} = Total time, in minutes per year, in which abatement system p has at least one associated tool in operation. For determining the amount of tool operating time, you may assume that tools that were installed for the whole of the year were operated for 525,600 minutes per year. For tools that were installed or uninstalled during the year, you must prorate the operating time to account for the days in which the tool was not installed; treat any partial day that a tool was installed as a full day (1,440 minutes) of tool operation. For an abatement system that has more than one connected tool, the tool operating time is 525,600 minutes per year if at least one tool was installed at all times throughout the year. If you have tools that are idle with no gas flow through the tool for part of the year, you may calculate total tool time using the actual time that gas is flowing through the tool.

i = Input gas.

j = Process sub-type or process type.

p = Abatement system.

(h) If you use fluorinated heat transfer fluids, you must calculate the annual emissions of fluorinated heat transfer fluids on a fab basis using the mass balance approach described in Equation I–16 of this subpart.

$$EH_i = density_i * (I_{iB} + P_i - N_i + R_i - I_{iE} - D_i) * 0.001 \qquad \text{(Eq. I-16)}$$

where:

EH_i = Emissions of fluorinated heat transfer fluid i, on a fab basis (metric tons/year).

$Density_i$ = Density of fluorinated heat transfer fluid i (kg/l).

I_{iB} = Inventory of fluorinated heat transfer fluid i, on a fab basis, in containers other than equipment at the beginning of the reporting year (in stock or storage) (l). The inventory at the beginning of the reporting year must be the same as the inventory at the end of the previous reporting year.

P_i = Acquisitions of fluorinated heat transfer fluid i, on a fab basis, during the reporting year (l), including amounts purchased from chemical suppliers, amounts purchased from equipment suppliers with or inside of equipment, and amounts returned to the facility after off-site recycling.

N_i = Total nameplate capacity (full and proper charge) of equipment that uses fluorinated heat transfer fluid i and that is newly installed in the fab during the reporting year (l).

R_i = Total nameplate capacity (full and proper charge) of equipment that uses fluorinated heat transfer fluid i and that is removed from service in the fab during the reporting year (l).

I_{iE} = Inventory of fluorinated heat transfer fluid i, on a fab basis, in containers other than equipment at the end of the reporting year (in stock or storage) (l). The inventory at the beginning of the reporting year must be the same as the inventory at the end of the previous reporting year.

D_i = Disbursements of fluorinated heat transfer fluid i, on a fab basis, during the reporting year, including amounts returned to chemical suppliers, sold with or inside of equipment, and sent off-site for verifiable recycling or destruction (l). Disbursements should include only amounts that are properly stored and transported so as to prevent emissions in transit.

0.001 = Conversion factor from kg to metric tons.

i = Fluorinated heat transfer fluid.

(1) If you use a fluorinated chemical both as a fluorinated heat transfer fluid and in other applications, you may calculate and report either emissions from all applications or from

only those specified in the definition of *fluorinated heat transfer fluids in § 98.98*.

(2) [Reserved]

(i) *Stack Test Method*. As an alternative to the default emission factor method in paragraph (a) of this section, you may calculate fab-level fluorinated GHG emissions using fab-specific emission factors developed from stack testing. To use the method in this paragraph, you must first make a preliminary estimate of the fluorinated GHG emissions from each stack system in the fab under paragraph (i)(1) of this section. You must then compare the preliminary estimate for each stack system to the criteria in paragraph (i)(2) of this section to determine whether the stack system meets the criteria for using the stack test method described in paragraph (i)(3) of this section or whether the stack system meets the criteria for using the method described in paragraph (i)(4) of this section to estimate emissions from the stack systems that are not tested.

(1) *Preliminary estimate of emissions by stack system in the fab*. You must calculate a preliminary estimate of the total annual emissions, on a metric ton CO_2e basis, of all fluorinated GHG from each stack system in the fab using default utilization and by-product formation rates as shown in Table I–11, I–12, I–13, I–14, or I–15 of this subpart, as applicable, and by using Equations I–8 and I–9 of this subpart. You must include any intermittent low-use fluorinated GHGs, as defined in § 98.98 of this subpart, in any preliminary estimates. When using Equations I–8 and I–9 of this subpart for the purposes of this paragraph (i)(1), you must also adhere to the procedures in paragraphs (i)(1)(i) to (iv) of this section to calculate preliminary estimates.

(i) When you are calculating preliminary estimates for the purpose of this paragraph (i)(1), you must consider the subscript ''j'' in Equations I–8 and I–9, and I–13 of this subpart to mean ''stack system'' instead of ''process sub-type or process type.'' For the value of a_{ij}, the fraction of input gas i that is used in tools with abatement systems, for use in Equations I–8 and I–9, you may use the ratio of the number of tools using input gas i that have abatement systems that are vented to the stack system for which you are calculating the preliminary estimate to the total number of tools using input gas i that are vented to that stack system, expressed as a decimal fraction. In calculating the preliminary estimates, you must account for the effect of any fluorinated GHG abatement system meeting the definition of abatement system in § 98.98. You may use this approach to determining a_{ij} only for this preliminary estimate.

(ii) You must use representative data from the previous reporting year to estimate the consumption of input gas i as calculated in Equation I–13 of this subpart and the fraction of input gas i destroyed in abatement systems for each stack system as calculated by Equation I–24 of this subpart. If you were not required to submit an annual report under subpart I for the previous reporting year and data from the previous reporting year are not available, you may estimate the consumption of input gas i and the fraction of input gas i destroyed in abatement systems based on representative operating data from a period of at least 30 days in the current reporting year. When calculating the consumption of input gas i using Equation I–13 of this subpart, the term ''f_{ij}'' is replaced with the ratio of the number of tools using input gas i that are vented to the stack system for which you are calculating the preliminary estimate to the total number of tools in the fab using input gas i, expressed as a decimal fraction. You may use this approach to determining f_{ij} only for this preliminary estimate.

(iii) You must use representative data from the previous reporting year to estimate the total uptime of all abatement systems for the stack system as calculated by Equation I–23 of this subpart, instead of using Equation I–15 of this subpart to calculate the average uptime factor. If you were not required to submit an annual report under subpart I for the previous reporting year and data from the previous reporting year are not available, you may estimate the total uptime of all abatement systems for the stack system based on representative operating data from a period of at least 30 days in the current reporting year.

(iv) If you anticipate an increase or decrease in annual consumption or emissions of any fluorinated GHG, or the number of tools connected to abatement systems greater than 10 percent for the current reporting year compared to the previous reporting year, you must account for the anticipated change in your preliminary estimate. You may account for such a change using a quantifiable metric (e.g., the ratio of the number tools that are expected to be vented to the stack system in the current year as compared to the previous reporting year, ratio of the expected number of wafer starts in the current reporting year as compared to the previous reporting year), engineering judgment, or other industry standard practice.

(2) *Method selection for stack systems in the fab*. If the calculations under paragraph (i)(1) of this section, as well as any subsequent annual measurements and calculations under this subpart, indicate that the stack system meets the criteria in paragraph (i)(2)(i) through (iii) of this section, then you may comply with either paragraph (i)(3) of this section (stack test method) or paragraph (i)(4) of this section (method to estimate emissions from the stack systems that are not tested). If the stack system does not meet all three criteria in paragraph (i)(2)(i) through (iii) of this section, then you must comply with the stack test method specified in paragraph (i)(3) of this section. For those fluorinated GHGs in Tables I–11, I–12, I–13, I–14, and I–15 of this subpart for which Table A–1 to subpart A of this part does not define a GWP value, you must use a value of 2,000 for the GWP in calculating metric ton CO_2e for that fluorinated GHG for use in paragraphs (i)(2)(i) through (iii) of this section.

(i) The sum of annual emissions of fluorinated GHGs from all of the combined stack systems that are not tested in the fab must be less than 10,000 metric ton CO_2e per year.

(ii) When all stack systems in the fab are ordered from lowest to highest emitting in metric ton CO_2e of fluorinated GHG per year, each of the stack systems that is not tested must be within the set of the fab's lowest emitting fluorinated GHG stack systems that together emit 15 percent or less of total CO_2e fluorinated GHG emissions from the fab.

(iii) Fluorinated GHG emissions from each of the stack systems that is not tested can only be attributed to particular process tools during the test (that is, the stack system that is not tested cannot be used as an alternative emission point or bypass stack system from other process tools not attributed to the untested stack system).

(3) *Stack system stack test method*. For each stack system in the fab for which testing is required, measure the emissions of each fluorinated GHG from the stack system by conducting an emission test. In addition, measure the fab-specific consumption of each fluorinated GHG by the tools that are vented to the stack systems tested. Measure emissions and consumption of each fluorinated GHG as specified in § 98.94(j). Develop fab-specific emission factors and calculate fab-level fluorinated GHG emissions using the procedures specified in paragraph (i)(3)(i) through (viii) of this section. All emissions test data and procedures used in developing emission factors must be documented and recorded according to § 98.97.

(i) You must measure, and, if applicable, apportion the fab-specific fluorinated GHG consumption of the tools that are vented to the stack systems that are tested during the emission test as specified in § 98.94(j)(3). Calculate the consumption for each fluorinated GHG for the test period.

(ii) You must calculate the emissions of each fluorinated GHG consumed as an input gas using Equation I–17 of this subpart and each fluorinated GHG formed as a by-product gas using Equation I–18 of this subpart and the procedures specified in paragraphs (i)(3)(ii)(A) through (E) of this section. If a stack system is comprised of multiple stacks, you must sum the emissions from each stack in the stack system when using Equation I–17 or Equation I–18 of this subpart.

$$E_{is} = MW_i * Q_j * \frac{1}{SV} * \frac{1}{10^3} * \sum_{s=1}^{N} \frac{X_{ism}}{10^9} * \Delta t_m \qquad \text{(Eq. I-17)}$$

Where:

E_{is} = Total fluorinated GHG input gas i, emitted from stack system s, during the sampling period (kg).

X_{ism} = Average concentration of fluorinated GHG input gas i in stack system s, during the time interval m (ppbv).

MW_i = Molecular weight of fluorinated GHG input gas i (g/g-mole).

Q_s = Flow rate of the stack system s, during the sampling period (m^3/min).

SV = Standard molar volume of gas (0.0240 m^3/g-mole at 68 °F and 1 atm).

Δt_m = Length of time interval m (minutes). Each time interval in the FTIR sampling period must be less than or equal to 60 minutes (for example an 8 hour sampling period would consist of at least 8 time intervals).

$1/10^3$ = Conversion factor (1 kilogram/1,000 grams).

i = Fluorinated GHG input gas.

s = Stack system.

N = Total number of time intervals m in sampling period.

m = Time interval.

$$E_{ks} = MW_k * Q_s * \frac{1}{SV} * \frac{1}{10^3} * \sum_{m=1}^{N} \frac{X_{ksm}}{10^9} * \Delta t_m \qquad \text{(Eq. I-18)}$$

Where:

E_{ks} = Total fluorinated GHG by-product gas k, emitted from stack system s, during the sampling period (kg).

X_{ks} = Average concentration of fluorinated GHG by-product gas k in stack system s, during the time interval m (ppbv).

MW_k = Molecular weight of the fluorinated GHG by-product gas k (g/g-mole).

Q_s = Flow rate of the stack system s, during the sampling period (m^3/min).

SV = Standard molar volume of gas (0.0240 m^3/g-mole at 68 °F and 1 atm).

Δt_m = Length of time interval m (minutes). Each time interval in the FTIR sampling period must be less than or equal to 60 minutes (for example an 8 hour sampling period would consist of at least 8 time intervals).

$1/10^3$ = Conversion factor (1 kilogram/1,000 grams).

k = Fluorinated GHG by-product gas.

s = Stack system.

N = Total number of time intervals m in sampling period.

m = Time interval.

(A) If a fluorinated GHG is consumed during the sampling period, but emissions are not detected, use one-half of the field detection limit you determined for that fluorinated GHG according to §98.94(j)(2) for the value of ''X_{ism}'' in Equation I–17.

(B) If a fluorinated GHG is consumed during the sampling period and detected intermittently during the sampling period, use the detected concentration for the value of ''X_{ism}'' in Equation I–17 when available and use one-half of the field detection limit you determined for that fluorinated GHG according to §98.94(j)(2) for the value of ''X_{ism}'' when the fluorinated GHG is not detected.

(C) If an expected or possible by-product, as listed in Table I–17 of this subpart, is detected intermittently during the sampling period, use the measured concentration for ''X_{ksm}'' in Equation I–18 when available and use one-half of the field detection limit you determined for that fluorinated GHG according to §98.94(j)(2) for the value of ''X_{ksm}'' when the fluorinated GHG is not detected.

(D) If a fluorinated GHG is not consumed during the sampling period and is an expected by-product gas as listed in Table I–17 of this subpart and is not detected during the sampling period, use one-half of the field detection limit you determined for that fluorinated GHG according to §98.94(j)(2) for the value of ''X_{ksm}'' in Equation I–18.

(E) If a fluorinated GHG is not consumed during the sampling period and is a possible by-product gas as listed in Table I–17 of this subpart, and is not detected during the sampling period, then assume zero emissions for that fluorinated GHG for the tested stack system.

(iii) You must calculate a fab-specific emission factor for each fluorinated GHG input gas consumed (in kg of fluorinated GHG emitted per kg of input gas i consumed) in the tools that vent to stack systems that are tested, as applicable, using Equation I–19 of this subpart. If the emissions of input gas i exceed the consumption of input gas i during the sampling period, then equate ‘‘E_{is}’’ to the consumption of input gas i and treat the difference between the emissions and consumption of input gas i as a by-product of the other input gases, using Equation I–20 of this subpart.

$$EF_{if} = \frac{\sum_s (E_{is})}{Activity_{if} * \left(UT_f + \left(\frac{1-UT_f}{1-(a_{if} * d_{if})} \right) \right)} \quad \text{(Eq. I-19)}$$

Where:

EF_{if} = Emission factor for fluorinated GHG input gas i, from fab f, representing 100 percent abatement system uptime (kg emitted/kg input gas consumed).

E_{is} = Mass emission of fluorinated GHG input gas i from stack system s, during the sampling period (kg emitted).

$Activity_{if}$ = Consumption of fluorinated GHG input gas i, for fab f, in the tools vented to the stack systems being tested, during the sampling period, as determined following the procedures specified in § 98.94(j)(3) (kg consumed).

UT_f = The total uptime of all abatement systems for fab f, during the sampling period, as calculated in Equation I–23 of this subpart (expressed as decimal fraction). If the stack system does not have abatement systems on the tools vented to the stack system, the value of this parameter is zero.

a_{if} = Fraction of fluorinated GHG input gas i used in fab f in tools with abatement systems (expressed as a decimal fraction).

d_{if} = Fraction of fluorinated GHG input gas i destroyed or removed in abatement systems connected to process tools in fab f, as calculated in Equation I–24 of this subpart (expressed as decimal fraction). If the stack system does not have abatement systems on the tools vented to the stack system, the value of this parameter is zero.

f = Fab.

i = Fluorinated GHG input gas.

s = Stack system.

(iv) You must calculate a fab-specific emission factor for each fluorinated GHG formed as a by-product (in kg of fluorinated GHG per kg of total fluorinated GHG consumed) in the tools vented to stack systems that are tested, as applicable, using Equation I–20 of this subpart. When calculating the by-product emission factor for an input gas for which emissions exceeded its consumption, exclude the consumption of that input gas from the term ‘‘$\Sigma(Activity_{if})$.’’

$$EF_{kf} = \frac{\sum_s (E_{ks})}{\sum_i (Activity_{if}) * \left(UT_f + \left(\frac{1-UT_f}{1-(a_f * d_{kf})} \right) \right)} \quad \text{(Eq. I-20)}$$

Where:

EF_{kf} = Emission factor for fluorinated GHG by-product gas k, from fab f, representing 100 percent abatement system uptime (kg emitted/kg of all input gases consumed in tools vented to stack systems that are tested).

E_{ks} = Mass emission of fluorinated GHG by-product gas k, emitted from stack system s, during the sampling period (kg emitted).

$Activity_{if}$ = Consumption of fluorinated GHG input gas i for fab f in tools vented to stack systems that are tested, during the sampling period as determined following the procedures specified in § 98.94(j)(3) (kg consumed).

UT_f = The total uptime of all abatement systems for fab f, during the sampling period, as calculated in Equation I–23 of this subpart (expressed as decimal fraction).

a_f = Fraction of all fluorinated input gases used in fab f in tools with abatement systems (expressed as a decimal fraction).

d_{kf} = Fraction of fluorinated GHG by-product gas k destroyed or removed in abatement systems connected to process tools in fab f, as calculated in Equation I–24 of this subpart (expressed as decimal fraction).

f = Fab.

i = Fluorinated GHG input gas.

k = Fluorinated GHG by-product gas.

s = Stack system.

(v) You must calculate annual fab-level emissions of each fluorinated GHG consumed using Equation I–21 of this section.

$$E_{if} = EF_{if} * C_{if} * UT_f + \frac{EF_{if}}{\left(1-(a_{if} * d_{if})\right)} * C_{if} * \left(1-UT_f\right) \quad \text{(Eq. I-21)}$$

Where:

E_{if} = Annual emissions of fluorinated GHG input gas i (kg/year) from the stack systems that are tested for fab f.

EF_{if} = Emission factor for fluorinated GHG input gas i emitted from fab f, as calculated in Equation I–19 of this subpart (kg emitted/kg input gas consumed).

C_{if} = Total consumption of fluorinated GHG input gas i in tools that are vented to stack systems that are tested, for fab f, for the reporting year, as calculated using Equation I–13 of this subpart (kg/year).

UT_f = The total uptime of all abatement systems for fab f, during the reporting year, as calculated using Equation I–23 of this subpart (expressed as a decimal fraction).

a_{if} = Fraction of fluorinated GHG input gas i used in fab f in tools with abatement systems (expressed as a decimal fraction).

d_{if} = Fraction of fluorinated GHG input gas i destroyed or removed in abatement systems connected to process tools in fab f that are included in the stack testing option, as calculated in Equation I–24 of this subpart (expressed as decimal fraction).

f = Fab.

i = Fluorinated GHG input gas.

(vi) You must calculate annual fab-level emissions of each fluorinated GHG by-product formed using Equation I–22 of this section.

$$E_{kf} = EF_{kf} * \sum_i C_{if} * UT_f + \frac{EF_{kf}}{\left(1-(a_f * d_{kf})\right)} * \sum_i C_{if} * \left(1-UT_f\right) \quad \text{(Eq. I-22)}$$

Where:

Ek_f = Annual emissions of fluorinated GHG by-product k (kg/year) from the stack systems that are tested for fab f.

EF_{kf} = Emission factor for fluorinated GHG by-product k, emitted from fab f, as calculated in Equation I–20 of this subpart (kg emitted/kg of all fluorinated input gases consumed).

C_{if} = Total consumption of fluorinated GHG input gas i in tools that are vented to stack systems that are tested, for fab f, for the reporting year, as calculated using Equation I–13 of this subpart.

UT_f = The total uptime of all abatement systems for fab f, during the reporting year as calculated using Equation I–23 of this subpart (expressed as a decimal fraction).

a_f = Fraction of fluorinated input gases used in fab f in tools with abatement systems (expressed as a decimal fraction).

dk_f = Fraction of fluorinated GHG by-product k destroyed or removed in abatement systems connected to process tools in fab f that are included in the stack testing option, as calculated in Equation I–24 of this subpart (expressed as decimal fraction).

f = Fab.

i = Fluorinated GHG input gas.

k = Fluorinated GHG by-product

(vii) When using the stack testing method described in this paragraph (i), you must calculate abatement system uptime on a fab basis using Equation I–23 of this subpart. When calculating abatement system uptime for use in Equation I–19 and I–20 of this subpart, you must evaluate the variables "Td_{pf}" and "UT_{pf}" for the sampling period instead of the reporting year.

$$UT_f = 1 - \frac{\sum_p Td_{pf}}{\sum_p UT_{pf}} \qquad \text{(Eq. I-23)}$$

Where:

UT_f = The average uptime factor for all abatement systems in fab f (expressed as a decimal fraction).

Td_{pf} = The total time, in minutes, that abatement system p, connected to process tool(s) in fab f, is not in operational mode as defined in § 98.98.

UT_{pf} = Total time, in minutes per year, in which the tool(s) connected at any point during the year to abatement system p, in fab f could be in operation. For determining the amount of tool operating time, you may assume that tools that were installed for the whole of the year were operated for 525,600 minutes per year. For tools that were installed or uninstalled during the year, you must prorate the operating time to account for the days in which the tool was not installed; treat any partial day that a tool was installed as a full day (1,440 minutes) of tool operation. For an abatement system that has more than one connected tool, the tool operating time is 525,600 minutes per year if there was at least one tool installed at all times throughout the year. If you have tools that are idle with no gas flow through the tool, you may calculate total tool time using the actual time that gas is flowing through the tool.

f = Fab.

p = Abatement system.

(viii) When using the stack testing option described in this paragraph (i), you must calculate the weighted-average fraction of fluorinated input gas i destroyed or removed in abatement systems for each fab f, as applicable, byusing Equation I–24 of this subpart.

$$d_{if} = \frac{\sum_j C_{ijf} * DRE_{ij}}{\sum_j C_{ijf}} \qquad \text{(Eq. I-24)}$$

Where:

d_{if} = The average weighted fraction of fluorinated GHG input gas i destroyed or removed in abatement systems in fab f (expressed as a decimal fraction).

C_{ijf} = The amount of fluorinated GHG input gas i consumed for process type j fed into abatement systems in fab f as calculated using Equation I–13 of this subpart (kg).

DRE_{ij} = Destruction or removal efficiency for fluorinated GHG input gas i in abatement systems connected to process tools where process type j is used (expressed as a decimal fraction) determined according to § 98.94(f).

f = fab.

i = Fluorinated GHG input gas.

j = Process type.

(4) *Method to calculate emissions from stack systems that are not tested.* You must calculate annual fab-level emissions of each fluorinated GHG input gas and by-product gas for those fluorinated GHG listed in paragraphs (i)(4)(i) and (ii) of this section using default utilization and by-product formation rates as shown in Tables I–11, I–12, I–13, I–14, or I–15 of this subpart, as applicable, and by using Equations I–8, I–9, and I–13 of this subpart. When using Equations I–8, I–9, and I–13 of this subpart to fulfill the requirements of this paragraph, you must use, in place of the term C_{ij} in each equation, the total consumption of each fluorinated GHG meeting the criteria in paragraph (i)(4)(i) of this section or that is used in tools vented to the stack systems that meet the criteria in paragraph (i)(4)(ii) of this section. You must use, in place of the term a_{ij}, the fraction of fluorinated GHG meeting the criteria in paragraph (i)(4)(i) of this section used in tools with abatement systems or that is used in tools with abatement systems that are vented to the stack

systems that meet the criteria in paragraph (i)(4)(ii) of this section. You also must use the results of Equation I–24 of this subpart in place of the terms d_{ij} in Equation I–8 of this subpart and d_{jk} in Equation I–9 of this subpart, and use the results of Equation I–23 of this subpart in place of the results of Equation I–15 of this subpart for the term UT_{ij}.

(i) Calculate emissions from consumption of each intermittent low-use fluorinated GHG as defined in § 98.98 of this subpart using the default utilization and by-product formation rates and equations specified in paragraph (i)(4) of this section. If a fluorinated GHG was not being used during the stack testing and does not meet the definition of intermittent low-use fluorinated GHG in § 98.98, then you must test the stack systems associated with the use of that fluorinated GHG at a time when that gas is in use at a magnitude that would allow you to determine an emission factor for that gas according to the procedures specified in paragraph (i)(3) of this section.

(ii) Calculate emissions from consumption of each fluorinated GHG used in tools vented to stack systems that meet the criteria specified in paragraphs (i)(2)(i) through (i)(2)(iii) of this section, and were not tested according to the procedures in paragraph (i)(3) of this section. Calculate emissions using the default utilization and by-product formation rates and equations specified in paragraph (i)(4) of this section. If you are using a fluorinated GHG not listed in Tables I–11, I–12, I–13, I–14, or I–15 of this subpart, then you must assume utilization and by-product formation rates of zero for that fluorinated GHG.

(5) To determine the total emissions of each fluorinated GHG from each fab under this stack testing option, you must sum the emissions of each fluorinated GHG determined from the procedures in paragraph (i)(3) of this section with the emissions of the same fluorinated GHG determined from the procedures in paragraph (i)(4) of this section. Sum the total emissions of each fluorinated GHG from all fabs at your facility to determine the facility-level emissions of each fluorinated GHG.

[75 FR 74818, Dec. 1, 2010, as amended at 76 FR 59551, Sept. 27, 2011; 77 FR 10380, Feb. 22, 2012; 78 FR 68202, Nov. 13, 2013; 79 FR 25682, May 6, 2014]

§ 98.94 Monitoring and QA/QC requirements.

(a) [Reserved]

(b) For purposes of Equation I–12 of this subpart, you must estimate fab-wide gas-specific heel factors for each container type for each gas used, according to the procedures in paragraphs (b)(1) through (b)(5) of this section. This paragraph (b) does not apply to fluorinated GHGs or N_2O that your fab uses in quantities of less than 50 kg in one reporting year and for which you calculate emissions as equal to consumption under § 98.93(a)(1), (a)(2), or (b), or for any intermittent low-use fluorinated GHG for which you calculate emissions according to § 98.93(i)(4)(i).

(1) Base your fab-wide gas-specific heel factors on the trigger point for change out of a container for each container size and type for each gas used. Fab-wide gas-specific heel factors must be expressed as the ratio of the trigger point for change out, in terms of mass, to the initial mass in the container, as determined by paragraphs (b)(2) and (3) of this section.

(2) The trigger points for change out you use to calculate fab-wide gas-specific heel factors in paragraph (b)(1) of this section must be determined by monitoring the mass or the pressure of your containers. If you monitor the pressure, convert the pressure to mass using the ideal gas law, as displayed in Equation I–25 of this subpart, with the appropriate Z value selected based upon the properties of the gas.

$$pV=ZnRT \qquad \text{(Eq. I-25)}$$

Where:

p = Absolute pressure of the gas (Pa).

V = Volume of the gas container (m^3).

Z = Compressibility factor.